Date of completion: 4 October 2006

HUMAN DESTINY AND THE BIOSPHERIC LIFE SUPPORT SYSTEM

John Cairns, Jr.

Department of Biological Sciences, Virginia Polytechnic Institute and State University,
Blacksburg, Virginia 24061, USA

ABSTRACT
The fossil record shows that all Earth's species have been transient. Yet humankind espouses sustainable development (which is based on continued human occupancy of the planet) despite the probability that Earth may last another 15 billion years. Is this expectation hubris, denial of scientific evidence, or failure to engage in any fundamental change in social norms? If unsustainable practices continue, leaving a habitable planet for posterity will not be possible. The most crucial determinant of human destiny on the planet is the continual health and integrity of the biospheric life support system, which has produced conditions (e.g., atmosphere gas balance) favorable to *Homo sapiens* for 160,000 years. If major alterations occur in the function of the biospheric life support system, present human social systems will be in disequilibrium, and even human survival will be in doubt.

What is past is prologue. William Shakespeare

The test of a first-rate intelligence is the ability to hold two opposed ideas in the mind at the same time, and still retain the ability to function.

F. Scott Fitzgerald

ANALYTICAL OBJECTIVES

- To call attention to human dependence upon the biospheric life support system, which creates and maintains conditions (e.g., atmospheric gas balance, temperature) that make the planet habitable for *Homo sapiens*
- To persuade readers that the biospheric life support system is being severely stressed and may be near or past its tipping point
- To persuade readers that humans are still basically a small-group species that does not sufficiently understand either the ecological or social systems of which each individual is a part
- To persuade readers that human numbers and activities have increased to a point where a 24% ecological overshoot has occurred —resources are being consumed far faster than the biospheric life support system can regenerate them. On a finite planet, this situation is unsustainable
- To emphasize that a cognitive dissonance exists between collective human behavior (high resource consumption) and aspirations (sustainable use of the planet)

THE BIOSPHERIC LIFE SUPPORT SYSTEM

1. Lovelock (1988: xvii) has remarked: "It is the health of the planet that matters, not that of some individual species of organisms" and "The health of the Earth is most threatened by major changes in natural systems." Earth maintained a markedly different atmosphere without life than it does at present (Lovelock 1988: 9).

Natural systems and the ecosystem services they provide collectively can be named the biospheric life support system. This discussion begins with the following assumptions:

2. Free market exponential growth has not encouraged an ethical relationship with other life forms or fellow humans.
3. If the biospheric life support system loses its equilibrium and evolves into a new state of equilibrium, that state is unlikely to be as favorable to humankind as the present system and may even be hazardous.
4. Major damage to the integrity of the biospheric life support system has resulted from anthropogenic activities, particularly in the last century.
5. Changes in human behavior and social norms, if based on scientific evidence, could markedly reduce stress on the biospheric life support system.
6. Damaged ecosystems can be restored if the delay is not too lengthy and appropriate species are available for recolonizing them.
7. Human population and consumption must be stabilized at a level compatible with Earth's carrying capacity.
8. The present ecological overshoot of approximately 24% must be eliminated.

ETHICS AND ECONOMICS

Human survival requires a resumption of the mutualistic coevolution of humans and the biospheric life support system (Cairns in press a). If humans intend to use natural systems sustainably, some rather formidable goals and conditions must be established and met (Cairns 2002). Since life on Earth has survived five great extinctions, it will probably survive a sixth; however, humans probably will not. To live sustainably for the 5-15 billion years the planet may have left will require more attention to ethics (Cairns 2003a, 2004). Since both human society and the biospheric life support system are dynamic, mutualistic adjustments in the relationship between the two systems will be continuous. The economic model of continuous economic development and growth on a finite planet (e.g., Simon 1980, 1981) endangers both the biospheric life support system and human security. Simon (1980) espoused an interesting, and now totally impractical, view on energy availability: "With respect to energy, it is particularly obvious that the Earth does not bound the quantity available to us. Our sun (and perhaps other suns) is the basic source of energy in the long run . . ." This pronouncement was published in the professional journal *Science* by a professor in a highly rated American university. Statements such as this one lull the general public and its leaders into a false sense of security and a disregard of ethical responsibility to posterity. In his introduction to another publication, Simon (1995) makes the astonishing statement: "Technology exists now to produce in virtually inexhaustible quantities just about all the products made by nature – foodstuffs, oil, and even pearls and diamonds – and make them cheaper in most cases than the cost of gathering them in the wild." No wonder the ethical relationship with natural systems appears to many people not to affect human survival. Worse yet, Simon states (1995):

> We have in our hands now – actually in our libraries – the technology to feed, clothe, and supply energy to an ever growing population for the next seven billion years . . . Indeed, the last necessary additions to this body of technology – nuclear fission and space travel – occurred several decades ago. Even if no new knowledge were ever invented after these advances, we would be able to go on increasing our population forever, while improving our standard of living and control over our environment.

Note the time spans – "seven billion years" and "forever." Some scientists are worried about humankind existing to the end of this century. As Brooymans (2006) notes, there is a collision of visions of the future between economics and ecology.

A major weakness in such metrics as gross domestic product (GDP) is its failure to measure the ecological efficiency with which humans achieve long and happy lives. This shortcoming occurs because the environmental costs are not major factors in the GDP. The happy planet index (Nef 2006) is a measure of both human well being and environmental impact. The Nef report notes that one of the prime indicators of sustainability, the ecological footprint, has two weaknesses: (1) it is extremely anthropocentric and does not include the biocapacity needed for other species and (2) available biocapacity can change, depending on the economic model, which does not include changes in natural resource availability (i.e., carrying capacity), and the manner of the natural resource model. The happy planet index (HPI) is defined as

$$\text{HPI} = \frac{\text{life satisfaction } x \text{ life expectancy}}{\text{ecological footprint}}$$

Despite its weaknesses, the ecological footprint is still one of the most useful metrics presently available, since it represents a snapshot in time of the consumption of natural resources. Overconsumption of natural resources impairs human security.

Humans constantly state "you can't stop progress," even when environmental factors are not sustainable (e.g., global warming and other types of climate change). However, nature (i.e., Gaia) can. Margulis describes nature as "a tough bitch" (quoted by Tickell 2006), and Lovelock (2006) describes the present situation as *The Revenge of Gaia*. China and the United States favor the economic growth model (as do many other nations) and the consequences (e.g., global warming) are now apparent to laypersons. Even so, the general belief is that further growth and development are possible. Massive evidence to the contrary is appearing in both scientific literature and the public news services daily; illustrative examples follow.

1. Around 5 million acres of land in Australia is now officially salt-affected (Byrnes 2006).
2. Southeast Asia is already losing billions to climate change and conditions appear to be worsening (Greenpeace 2006).
3. In the United States, sudden wetland diebacks are occurring in New England (New England Estuarine Research 2006).
4. The entire planet is losing species faster than at any time in the last 65 million years (when Earth was hit by an enormous asteroid). The present rate of loss is caused primarily by human activities (Connor 2006).

These and numerous other environmental catastrophes are due to a failure in eco-ethics. Most ethical systems are homocentric – that is, they are devoted to human relationships. Eco-ethics is ecocentric – that is, the primary focus is on the interdependent web of life, of which humans are a part. Homocentric ethics is a human construct because cheap, readily available energy has temporarily given humans more power than any other species. However, since humans are destroying the biospheric life support system, enlightened self interest dictates that humans become ecocentric and preserve their support system as a matter of security.

Signs of positive developments have surfaced in eco-ethics. Speth and Haas (2006) explain how societies addressed environmental problems in the past and what needs to done in the future. Weisman (2006) describes how business schools have failed to define leadership in the context of the public good and enshrined as their highest ideal the maximizing of shareholder value. At the same time, economic losses due to weather are almost off the charts (Stephen Leeb, author of *The Coming Economic Collapse,* as quoted by Lewis 2006). Humankind is in an era of unprecedented levels of economic activity set against a backdrop of ecological decline, also unprecedented in human history (Worldwatch Institute 2006). Clearly, the economic model of continuous exponential growth is not compatible with the ecological model that espouses the well being of the biospheric life support system. Hawken et al. (1999) provide persuasive evidence that industries can increase profits, production, and employment via efficiencies that reduce energy and materials consumption by as much as 90%. Diamond (2005) provides a detailed description of the history and ethics of societies that failed as well as ones that succeeded. These ethical dilemmas must be resolved in the 21st century. The unifying theme between economics and ecology is an ethical model that permits both to flourish, which will require resource partitioning and reuse, which follows nature's model.

MAJOR DAMAGE TO THE INTEGRITY OF THE BIOSPHERIC LIFE SUPPORT SYSTEM

Human security will be seriously impaired if global climate change reduces food supplies and the availability of fresh water. If resource regeneration is diminished, the current ecological overshoot will be exacerbated. These conditions are far from ideal for implementing increased protection and repair of the biospheric life support system. The depletion of resources and their decreased availability might well intensify resource wars at all levels of societal organization. Wars deplete resources without significantly increasing global or local security. These circumstances would impair security both by diverting badly needed resources toward warfare and by diminishing resource generation because of various stresses caused by climate change.

Humankind is using natural resources faster than they are being regenerated (Wackernagel et al. 2002; Meadows, D., J. Randers, and D. Meadows 2004). Clearly, this ecological overshoot cannot be sustained on a finite planet. A useful metaphor is a secretive person who is living on the interest from a bank account. However, this person discovers that an even better life is possible by using some of the capital in the account. Consequently, less capital accrues less interest, which means more capital is used continuously. An outsider might think nothing has changed, but the "party" will soon be over. One major problem in ecological overshoot is that the world's commons (e.g., oceans, atmosphere) are unmanaged (Cairns 2003b). In fact, the entire planet is effectively a commons since any person or organization with adequate funds can gain access to resources anywhere in the world. Humankind's enlightened self interest demands that the biospheric life support system retain sufficient resources to function properly. The ecological overshoot must be eliminated.

Resource distribution among humans is far from equitable and dramatically different from resource partitioning in natural systems. Every species experiences unequal resource distribution throughout its niche.

Other species die or suffer when resources decline. Humans have reduced the impact of resource scarcity by domesticating plants and animals and by acquiring what Catton (1982) called "ghost slaves." A ghost slave is the equivalent of how much energy one human could spend in one day (2,000-3,000 kilocalories). As Catton (1982) notes, by substituting fossil energy for muscle power, the per capita energy use in the United States reached a level equivalent to approximately 80 ghost slaves per citizen. This situation produces deleterious effects upon both social and ecological systems. Instability in either or both is a major threat to human security.

CHANGES IN HUMAN BEHAVIOR

American citizens developed a great fear of terrorists after high jacked planes were flown into the World Trade Center Buildings and the Pentagon. Despite the shock of this event, individual citizens are not at great risk from terrorists. Individuals are much more likely to be killed by a drunken driver or endure ill health from being overweight, smoking cigarettes, and the like National Geographic 2006).

In the United States, a peculiar attitude exists toward the risks of plane travel. During the summer 2006 terrorist events in the United Kingdom, the United States was on a lowered terrorist treat notice (yellow). A risk conscious person might reasonably avoid a yellow alert since the Department of Homeland Security indicates that a yellow alert means no special inspections of passengers or cargo. A good day for air travel would be red or orange alert days since terrorists would realize that their chances of being discovered are greater because of increased security checks. However, many US citizens face much greater risks than terrorists: (1) 45 million people have no health insurance, (2) 4,300,000 people were injured, made sick, or killed while working in 2005, (3) many corporations have raided or eliminated pension funds, (4) global warming and other types of climate change have increased the risks from droughts, forest fires, and flooding as well as increased storm intensity, (5) other familiar risks are drunk drivers, AIDS, and handguns. Is the American perception of risk biased towards fear of terrorists? The National Safety Council (*National Geographic*, 2006, p. 21) has charted the lifetime probabilities of an American resident dying in a relatively common event, such as a pedestrian accident (1 in 626), or a less common but larger scale catastrophe, such as an earthquake (1 in 117,127). Terrorism is not even mentioned, although death from fireworks discharge is (1 in 340,733). The partial recolonization of New Orleans, LA, after Hurricane Katrina is praised, almost eulogized by Gaines (2006), even though his article is followed by graphic photographs of the appalling damage done by Hurricane Katrina (Burnett 2006) and a plethora of reports that storm intensities are increasing. To his credit, Gaines (2006) does not trivialize the damage to either the people or the city. However, he writes: "There will be town meetings, and there will be private citizens screaming at politicians, but in the end New Orleans will be rebuilt. Le us not worry there will always be a New Orleans." Certainly the ambiance should be restored, but does it have to be in a location that places people and property at risk? Surely the ambiance is not site specific, but a frame of mind.

Hurricane Katrina reached the US Gulf Coast in late August 2005 and forced a million people from New Orleans and the small coastal towns to move inland either within the state or to neighboring states, such as Texas and Arkansas (Brown 2006). Nearly all planned to return; many have not. A US federal judge ruled that the storm-induced surges of Hurricane Katrina were floods and therefore not covered by standard homeowner policies (Day 2006).

The increased intensity of hurricanes is a risk most people in the path of the ferocious forces of nature have yet to factor fully into their future plans. Insurance companies are well aware of the increased risk and are adjusting the rates of their policies accordingly. Hurricanes are fueled by heat, which provides energy for the storms by sending warm, moist air rushing toward the cooler, upper atmosphere. Storm surges exacerbate an already serious problem. Coastal development weakens the natural defenses against storm surges. For example, barrier islands and wetlands can buffer surges (Hayden 2006). Channels dredged for boat traffic in the marshlands allow salt water into the back marshes, killing the vegetation that holds them together. In addition, dikes and levees cut off sediment transfer so that more than 20% of Louisiana's coastal wetlands reverted to open water from 1950 to 2000 (Hayden 2006). As these natural defenses are damaged or disappear, the security of increasingly large inland populations will be at risk.

Although plans have been proposed to keep global atmospheric carbon dioxide in check, present rates of growth emissions will double by 2056 (Socolow and Pacala 2006). After 2056, emissions might stabilize or even decline if new technologies and energy policies are effective. For example, former US Vice President Al Gore (2006; available at http://www.nyu.edu/community/gore.html) proposed an immediate freeze on all emissions of carbon dioxide and then the beginning sharp reductions.

ACCEPTING UNCERTAINTY AND CHANGE

Human security requires that humankind respect both human and nonhuman knowledge (e.g., Czech 2001) and understand uncertainty in science and life, the scientific process, evolutionary processes, humankind's dependence upon nonhuman life forms, and accept that spirituality does not exempt anyone from the laws of

nature. The cumulative impact of seemingly insignificant human decisions resulted in the present serious threat to human security. In short, individual decisions have produced the present threats to human society (e.g., global warming), and individual decisions, in harmony with natural law (e.g., carrying capacity), can reduce, perhaps even eliminate, the threats. Not all risks can be eliminated, such as the impact of Earth with a large object from outer space. However, human security can be markedly improved by replacing unsustainable practices with sustainable ones. Above all, the major, but not sufficient, component of human security is the health and integrity of the biospheric life support system. For terrestrial ecosystems, precautionary measures must be taken despite uncertainty because of the dramatic changes now underway.

TERRESTRIAL ECOSYSTEMS

Scholze and colleagues (2006) have used simulations of the world's climate to predict varying amounts of global warming by 2100 in three categories: (1) less than 2C, (2) 2C-3C, and (3) more than 3C (Jha 2006). Scholze states that a 2C rise was inevitable, even if the world immediately stopped emitting greenhouse gases. This scenario predicts that Europe, Asia, Canada, Central America, and Amazonia could lose up to 30% of their forests. A rise of 2C-3C would mean less water available in the eastern and southern portions of the United States, West Africa, Central America, and southern Europe, raising the probability of drought in these areas. In contrast, the tropical parts of Africa and South America would be at greater risk of flooding as trees are lost. None of these outcomes bode well for human security. Scholze also predicts that a global temperature rise of more than 3C would mean even less fresh water. Loss of forests in Amazonia, Europe, Asia, Canada, and Central America could reach 60%. Surely these situations could be accurately described as catastrophic.

Satellite monitoring has made increased the awareness of the appalling rate of deforestation of the Amazon basin, sometimes referred to as "the lungs of the world." In the past three years, nearly 70,000 square kilometers of the Amazon rainforest have been destroyed (Howden 2006). Much land is being cleared for soya production, but within as little as three years, the land could be reduced to a desert. Then another area would be opened for soya. An Amazon rainforest deforestation problem existed previously due to cattle ranching, illegal logging, and land speculation long before soya appeared on the scene. In addition, although Cargill Corporation appears to be a primary target of environmentalists, the entire production of the 150 little farms that sell soya to Cargill is about 60,000 tons or about 1% of the Amazon soya production. Cautious optimism is justified, however. Ginn (2006) reports the purchase from private timber companies in the United States (e.g., International Paper) of huge tracts of land by the Nature Conservancy. This purchase will prevent timbered areas from being developed for housing and shopping malls.

Macartney (2006) describes a present day grim situation in China where millions of farmers could be facing starvation. In China's "grain basket," central Sichuan Province, millions of acres of crops have withered, and, across the country, more than 6 million acres have been ruined – an area 21% larger than in previous years. This occurrence is somewhat similar to the "dead zones" in marine ecosystems (e.g., Frazier 2006). In both marine and terrestrial systems, these zones are a threat to human security because they are not generating resources in amounts similar to historic rates. In terrestrial systems, these reductions in resource generation are often due to water shortages. Vidal (2006) notes that these reductions could cause economic collapse, civil unrest, and mass migration. China's industrial city of Chongqing and parts of neighboring Hunan Province have experienced a drought in summer 2006, which has caused drinking water shortages for 7.8 million people (Associated Press 2006).

These risks are familiar, so people tend to discount or ignore them. Also, humans tend not to fear activities they view as under their control, such as overeating. Similarly, the risk of diminished food supply due to a variety of consequences of climate change do not generate as much fear as terrorists despite the probability that a markedly diminished food supply could kill and starve millions, even billions, of people. Global warming has already caused catastrophic events in parts of the planet, and conditions continue to worsen despite some commendable attempts to avoid disaster. Individuals often comment that they can do very little about global problems. However, the cumulative impact of massive numbers of individual decisions has caused the increase in greenhouse gases, so individuals can diminish the problem if enough people feel a responsibility for causing the problem. To quote the comic strip character Pogo, "We have met the enemy and he is us." Human security requires an accurate perception of risk.

Many strategies exist for reducing risk. For example, David Miliband, the United Kingdom's environmental minister, unveiled a radical plan to reduce greenhouse gas emissions by charging individuals for the amount of carbon they use (Adam and Batty 2006). Arguably, one of the best books on the consequences of not reducing environmental risks is Lovelock's (2006) *The Revenge of Gaia*. The Gaia hypothesis proposes that the entire Earth functions as a single, living superorganism, regulating its internal environment much as an animal regulates its body temperature. Lovelock believes that the superorganism (called the biospheric life support system in this article) is sick. Lovelock asserts that it is already too late to prevent the global climate

from “flipping into an entirely new equilibrium that will threaten humanity” but feels much can still be done to save humanity. Humans are at the greatest risk in this situation. Sachs (2006) carries the scenario further by commenting on the political upheaval that will result as a consequence of ecological damage.

Global freshwater shortages (a major limiting factor in the human ecological niche) are becoming a major societal and ecological problem (e.g., Pearce 2006; de Wit and Stankiewicz 2006), as is the rapidly increasing gap between rich and poor (Tritch 2006). Previously, the contrast between rich, middle class, and poor was recognizable globally and it has been absolutely stunning in some places, then and now. At present, the contrast is increasingly between a tiny class of the ultra-rich (less than 1% of the American population) and everyone else. Some of the super-rich gains reflect capitalism’s robust rewards for the founders of Microsoft, Google, and Dell. However, the difference is mostly due to the unprecedented largesse given to executives in the form of salary bonuses and stock options. The super-rich also benefit from strong returns on investment income. For example, in 2003, the top 1% of the American households owned 57.5% of the corporate wealth. However, as Durant and Durant (1968) note, whenever the gap between the very rich and the very poor becomes too great, there is always a partial redistribution through either revolution or social change. As both Durant and Durant (1968) and Tritch (2006) remark, a fair and well functioning economy will always involve some inequality. However, inequality is generally considered to be dangerous when it becomes so extreme as to be self reinforcing. This situation is not supportive of human security, especially when coupled with numerous environmental problems.

POLARIZATION OF SCIENCE

Another major threat to human security is the politization of science. For example, the US National Aeronautics and Space Administration (NASA) mission statement prominently featured in its budget and planning documents the phrase “To understand and protect our home planet.” In February 2006, this phrase was quietly deleted. David Steitz said, for NASA, that the aim was to square the statement with US President Bush’ goal of pursuing human spaceflight to the moon and Mars (Revkin 2006). With Earth in an ecological crisis that threatens human security, one wonders why the phrase had to be deleted. In an era when climate change is accepted as the major threat to human security (e.g., Walters 2006), trips to the moon and Mars seem almost frivolous – even a diversion from the primary issue. Sandell and Blakemore (2006) describe the profits available from creating confusion over global warming. In short, such attempts at obfuscation pretend that humans need not change their behaviors. In the US state of Virginia, Patrick Michaels, the state climatologist, who is also a faculty member at the University of Virginia, has been chastised for shilling for polluters (Editorial 2006). The large sums of money received have damaged his creditability as a supposedly neutral academic in a contentious debate (Michaels 1992; Michaels and Balline 2000). Recently, much media attention has been given to this issue. For example, the Governor’s Office has asked Virginia climatologist Michaels to refrain from using his title when conducting non-state business because of fears his views on global warming would be perceived as an official state position (Editorial 2006). To make matters more confusing, Michaels is on a one-year leave teaching a class on global warming, among other topics, at a Virginia Tech satellite campus in Northern Virginia. Teaching should be based on the preponderance of scientific evidence, not giving each point of view equal time, especially when that point of view is not congruent with mainstream science. However, when many people and corporations are reluctant to change their behavior, publications that do not take a neutral stance may provide a rationale for not doing so. Consequently, as long as many people and corporation find it profitable not to change their behavior, publications that support this attitude tend to attract monetary rewards from influential groups.

However, many events in people’s lives globally provide a strong incentive to change, such as water shortages in many areas and recycled sewage added to drinking water supplies (Koch and Roberts 2006). One major problem with recycled sewage being added to drinking water is that hormones left in the recycled sewage could cause “changes in the basic metabolism of species” (Koch and Roberts 2006). This situation has, for example, caused feminization of fish and might also for other species. On the US state of Florida’s Gulf Coast, harmful algal blooms have become much more common, producing respiratory afflictions, dead fish, and noxious odors (Weiss 2006). The offending red tides, once a freak of nature, are now becoming commonplace. They also contaminate popular seafood and can cause neurotoxic shellfish poisoning.

Such personal experiences tend to persuade people to change their behavior, despite assertions from some that not much is wrong environmentally (e.g., Lomborg 2001). These occurrences and other similar events are just Earth fighting back (Lovelock 2006).

HUMAN BEHAVIOR: SMALL GROUP/LARGE GROUP EVOLUTION

Humans began as a small-group species that is now living in huge groups bearing little resemblance to tribes. Social evolution has not even progressed to the early stages of globalization. Yet humankind must function

adequately at both local and global levels if sustainable use of the planet has even a modest chance of succeeding. Thinking globally and locally simultaneously and effectively may seem an impossible task, but sustainable use of the planet makes such thinking mandatory. In 2006, the signs of global ecological disequilibrium have become unmistakable to anyone with minimal scientific literacy. Yet only modest efforts are being made to stop the trends that produced this major threat to human security. As Rees (1996) notes, most so-called "advanced" countries are running massive unaccounted ecological deficits with the other parts of the world. Even the prophetic World Scientists' Warning to Humanity (Union of Concerned Scientists 1992) has been essentially ignored. At present, seemingly overnight, consequences that seemed decades or centuries away are already occurring. Frozen water on the planet is melting rapidly, and, in the tropics, an unprecedented spread of mosquito-borne diseases is occurring. These events are usually not associated with human security, although they are crucial. Worse yet, humankind's energy-dependent technological infrastructure is faced with the end of cheap, abundant, and convenient oil supplies, coupled with an increased demand for oil. Alternative fossil fuels, such as coal, are less attractive than they appear since, if humans do not dramatically decrease fossil fuel use, these trends that undermine human security will accelerate further. However, long-overdue changes to sustainable societies and economics based on natural capital will both increase human security and satisfaction as well as establish a harmonious relationship with other life forms.

One major societal change must be the elimination of war as a means of resolving disputes (e.g., the oil spill caused by an Israeli attack on Lebanon; Noueihed 2006). War wastes resources more than any other activity and has, historically, failed to benefit human security. When a US F-16 plane activates its afterburners, it consumes almost 28 gallons of fuel per minute, and the Abrams tank gets less than a mile per gallon under certain combat conditions (Shanker 2006). Visualize the improvement in human security from replacing military expenditures with ecological restoration and preservation, which would increase natural capital, upon which all other forms of capital depend, and the ecosystem services that natural capital provides, upon which human life depends. Other life forms have no political agenda and few, if any, of the biases that influence human actions. The biospheric life support system unwittingly (e.g., Mercuro, Lopez, and Preston 1994) favors humans at this time, but the continuance of favorable conditions is jeopardized if human activities continue to place the biospheric life support system into disequilibrium. Since the biospheric life support system is an important component of human security, maintaining its health and integrity should be a societal goal more important than any other. The biospheric life support system should not be neglected or ignored because of fixations on other goals such as economic growth and the like. The goal of sustainable use of the planet is to permit indefinite human presence and to maintain and improve the health and integrity of the biospheric life support system that is essential to this goal. The irony is that natural capital (e.g., Czech 2000) has been used to produce the knowledge and technology that is destroying it.

ENERGY AND SECURITY

Homo sapiens has exploited vast reservoirs of fossil fuels to achieve a dominant status that other species cannot match. This release of vast amounts of stored energy has enabled humans to modify their environment to suit human needs and vastly increase their resource base. This gain permitted an exponential growth of the human population while concomitantly increasing per capita affluence. These factors increased human security despite wars and economic downturns. Heinberg (2005) has illustrated (his figures 1 and 2, p. 31) the close correlation between oil production and human population size – as oil production begins a sharp decline in the 21st century, human population declines from 7 billion to well under 4 billion. Basically, Heinberg assumes that no environmentally satisfactory substitute for cheap, readily available petroleum will be available. This situation, together with global warming and other types of climate change (e.g., rainfall patterns), will markedly decrease production of foodstuffs. Asimov (1991, quoted by Heinberg 2005, p. 9) has stated: "The ability to control energy, whether it be making wood fires or building power plants, is a prerequisite for civilization."

As Price (1995) notes: "The human species may be seen as having evolved in the service of entropy, and it cannot be expected to outlast the dense accumulations of energy that helped define its niche." Price believed that the collapse of the human population would correspond closely to the disappearance of abundant, cheap energy. The quest for sustainable use of the planet is based on the assumption that humans can achieve a harmonious, mutualistic relationship with the biospheric life support system, but, in 2006, this goal seems quite distant. From a human time perspective, some sources of energy are renewable (e.g., wood, sunlight); others are not (fossil fuels). Sustainable use of the planet, which is at least still theoretically possible, is intended to provide ecological security for humans indefinitely. Sustainability assumes the human population can set and reset their demands upon natural systems so they will be congruent with changing carrying capacity (i.e., biocapacity) in a dynamic equilibrium with Earth's carrying capacity for humans. However, nature makes no provision for maintaining a population that violates carrying capacity limits. Worse yet, severe penalties are assessed for reducing carrying capacity as both climate change and reduced availability of cheap, plentiful fuel

are now showing. In fact, burning fossil fuels exacerbates the carrying capacity problem, and major unresolved issues (e.g., disposal of spent nuclear fuel rods) still exist for nuclear power plants. Human security depends upon scientifically robust solutions to these problems.

RESTORING DAMAGED ECOSYSTEMS

The four-year Millennium Ecosystem Assessment dated 31 March 2005 and authorized by the United Nations studied 24 major ecosystems that support the human economy. Of these, 15 are being pushed beyond their sustainable limits or are already being degraded. The primary message is simple: many of Earth's biospheric life support systems are in danger. Ecological restoration of these damaged systems is the way to improve human security. Ecological restoration of these damaged systems is not only a way to improve human security but a much better way than just adapting to reduced services. However ecological restoration will be a challenge in an era of ecological disequilibrium (Cairns 2006a). For those unfamiliar with the field of ecological restoration, a useful source is *Restoration of Aquatic Ecosystems: Science, Technology, and Public Policy* (National Research Council 1992), which includes numerous case histories.

HUMAN POPULATION

Although the human population continues to grow exponentially (US Bureau of the Census, International Data Base 2005), the world's grain harvest of wheat, rice, corn, and other grains, which made up the majority of the human diet in 2005 at 2.015 million tons (Halweil 2006), is not growing and even decreases in some years. In addition, some of this production, such as corn, is being diverted to automotive fuel production and meat production. Fortunately, the wheat harvest increased substantially in some low income, food deficient countries (Halweil 2006). Ironically, obesity has become a common disease elsewhere (World Health Organization 2003), which can lead to cardiovascular disease, osteoporosis, and depression. Finally, in 2006, global warming and other types of climate change appear to be threatening production of foodstuffs, as does diminished supplies of fresh water. Of course, population stabilization at a level congruent with resource availability on a finite planet is essential to sustainable use of the planet. However, the United States, which is one of the world's top consumers of resources per capita, is still engaged in a political battle over contraception (Feldt 2006). This indecision has also had a negative effect on birth control aid to countries where women cannot afford contraceptive materials. If China and India both grow and claim their fair share of the planet's resources, the present dire situation will be exacerbated, posing an even greater threat to human security.

ECOLOGICAL OVERSHOOT

Ecological overshoot has already been discussed briefly, but, since it is a major threat to human security, it deserves more attention because it is not sustainable. Simply stated, overshoot is using resources faster than Earth can regenerate them. By doing so, humans are "eating" posterity's future (Cairns 2006b), a rather poor inheritance for future generations. The existing 24% overshoot is a monumental problem, but is worsened by three major factors: (1) resource wars, such as the one in Iraq and others elsewhere (Reuters 2006), increase resource use and damage natural systems, thus decreasing resource regeneration, (2) global warming and other types of climate change (e.g., altered rainfall patterns) adversely affect resource regeneration, thus diminishing the amount available for use, (3) global warming has produced some positive feedback loops, exacerbating an already difficult situation. For example, the smothering heat wave in the United States has substantially increased power use for air conditioners (Pérez-Peña and Wald 2006). Electricity generation by fossil fuel power plants adds carbon dioxide to the atmosphere, thus accelerating global warming. If pleas for voluntary power conservation are ineffective, rolling blackouts are the probable result. As pointed out above, an effective way to increase ecological capital is to restore damaged ecosystems (Cairns 2005). Restoration efforts would increase human security and, thus, are worth the effort. However, as Sutherland (2006) notes, predicting the ecological consequences of environmental change is difficult and policy and decision making often seems surprisingly divorced from ecological research.

THE CONCEPTUAL GULF BETWEEN ECONOMICS AND ECOLOGY

A vast conceptual gulf exists between economics, which is growth oriented and has created a 24% ecological overshoot in achieving this goal, and ecology, which espouses sustainable use of natural resources. Fortunately, indications are that this gulf is narrowing, but not rapidly enough to avoid catastrophes that endanger human security. Corporations are profit seeking entities and, in some countries, are required by law to hold to this priority. However, the public and its representatives are all too often poorly informed about these issues. Paul Ehrlich (personal communication) kindly shared with me a preprint of an address by Partha Dasguta (the address is to be delivered in September 2006 at the annual conference of the British Ecological Society; Dasgupta is the Frank Ramsey Professor of Economics at the University of Cambridge and a Fellow of

St. John's College, Cambridge.), the comments of William Rees to the address, and a response from Dasgupta to the comments by Rees. Essentially, Dasgupta agreed with the comments of Rees, which are congruent with those made in this article. If a consilience (literally "leaping together") occurs between economics and ecology, I believe it will be strongly influenced by ethics. Dasgupta discusses the "World Bank view" of the recent macroeconomic history of a number of countries in the poor and rich worlds, but, of great importance for ecologists, is how very different macroeconomic history begins to look if nature is included as a capital asset in production activities.

Dasgupta is clearly an economist who gives natural systems more attention than do most economists, but some of his assumptions are not yet validated:

1. Natural capital and ecosystem services can be replaced by either other types of capital (e.g., manufactured products) or technological services. This assumption allows the productive base of a nation to increase even if it liquidates essential natural capital.
2. Ecosystem damage is both predictable and reversible. In an era of ecological disequilibrium, neither of these assumptions are justified (Cairns in press b), and available evidence indicates they are very weak assumptions.
3. Natural capital can be priced at the margin. This assumption is also weak and closely linked to assumption #4 (detailed discussion in Ackerman and Heinzerling 2004).
4. Natural capital is more or less commensurate with manufactured capital. This assumption is badly mauled by Hawken et al. (1999).

Clearly, much needs to be done before a consilience of nature and humankind's economic systems are achieved. Abundant evidence indicates that corporations frequently either ignore or bypass government regulations and, in the United States, have numerous well financed lobbyists to persuade politicians of severe economic consequences if regulations are enforced. The public is poorly prepared to cope with these complex issues. As a consequence, they are unaware of their responsibilities as citizens.

CONCLUDING STATEMENT

For a high per capita energy use society, such as the United States, the issues just discussed seem grim. However, the Nef (2006) index of human well being and environmental impact frames these issues in a different perspective. A major conclusion of the Nef report is that well being does not rely on high levels of consumption. The United Kingdom's ecological footprint, the 18th largest worldwide, produced an unspectacular 108th place in the HPI rating of 178 countries. A typical US citizen consumes over five times his/her share of the world's resources, but is ranked only 150th (out of 178) in the happy planet index (HPI). Germany is about twice as efficient as the United States at generating long, happy lives in terms of the resources it consumes. The Nef (2006) report addresses the relative success or failure of countries in supporting a good life for their citizens, while respecting the environmental resource limits upon which all human lives depend. Ecological efficiency could be markedly improved while concomitantly improving both life satisfaction and life expectancy. Living within resource limits means that human security would also be markedly improved.

Acknowledgments. I am indebted to Darla Donald for transcribing several drafts and for editorial assistance.

LITERATURE CITED

Ackerman, F. and Heinzerling. 2004. *Priceless: On Knowing the Price of Everything and the Value of Nothing*. The New Press, New York (distributed by W. W. Norton and Company, NY).

Adam, D. and D. Batty. 2006. Miliband unveils carbon swipe-card plan. *Guardian Unlimited* 19 July http://www.guardian.co.uk/climatechange/story/0,,1824241,00.html.

Associated Press. 2006. Heat, drought strain China's power, water resources. *Environmental News Network* 17 August http://www.enn.com/today.html?id=11078.

Brooymans, H. 2006. Visions for the future collide. *The Edmonton Journal* 28 July http://www.canada.com/edmontonjournal/news/story.html:id=f41ecd90-475b-4ef8-8869-64f038595027&k=28814.

Brown, L. R. 2006. Global warming forcing U.S. coastal population to move inland: an estimated 250,000 Katrina evacuees are now climate refugees. *Earth Policy Institute* 16 August http://www.earth-policy.org/Updates/2006/Update57.htm.

Burnett, D. 2006. Home no more. *National Geographic* 210(2):42-53.

Byrnes, M. 2006. Killer salinity rings Australia's desert heart. *Reuters* 18 July http://www.reuters.com/newsArticle.jhtml?type=ourWorldNews&storyID=12877196&src=rss/lifeAndLeisureNews.
Cairns, J., Jr. 2002. *Goals and Conditions for a Sustainable World*. Ethics in Science and Environmental Politics, Eco-Ethics International Union, Odendorf/Luhe, Germany. http://www.esep.de/journals/esep/esepbooks/CairnsEsepBook.pdf.
Cairns, J., Jr. 2003a. *Eco-Ethics and Sustainability Ethics, Part I*. Ethics in Science and Environmental Politics, Eco-Ethics International Union, Odendorf/Luhe, Germany. http://www.esep.de/journals/esep/esepbooks/EB2pt1.pdf.
Cairns, J., Jr. 2003b. The unmanaged commons: a major challenge for sustainability ethics. *The Social Contract* XIV(2):136-145.
Cairns, J., Jr. 2004. *Eco-Ethics and Sustainability Ethics, Part 2*. Ethics in Science and Environmental Politics, Eco-Ethics International Union, Odendorf/Luhe, Germany. http://www.esep.de/journals/esep/esepbooks/EB2pt2.pdf.
Cairns, J., Jr. 2005. Ecological overshoot and ecological restoration. *Asian Journal of Experimental Sciences* 19(2):1-12.
Cairns, J., Jr. 2006a. Ecological restoration in an era of ecological disequilibrium. *Asian Journal of Experimental Sciences* 20(1):1-6.
Cairns, J., Jr. 2006b. Future eaters. *Commentaries* http://www.johncairns.net.
Cairns, J., Jr. In press a. Sustainable coevolution. *International Journal of Sustainable Development and World Ecology.*
Cairns, J., Jr. In press b. Ecological restoration in an era of ecological disequilibrium. *Asian Journal of Experimental Sciences*.
Connor, S. 2006. Earth faces 'catastrophic loss of species. *The Independent* 20 July http://www.news.independent.co.uk/world/science_technology/article1187003.ece.
Czech, B. 2000. Economic growth as the limiting factor for wildlife conservation. *Wildlife Society Bulletin* 28(1): 4-14.
Czech, B. 2001. Incorporating nonhuman knowledge into the philosophy of science. *Wildlife Society Bulletin* 29(2): 665-674.
Day, K. 2006. Storm surge is flood, judge says: standard insurance won't cover damage. *Washington Post* 16 August http://www.washi ngtonpost.com/wp-dyn/content/article/2006/08/15/AR2006081500584.html.
de Wit, M. and J. Stankiewicz. 2006. Changes in surface water supply across African with predicted climate change. *Science* 311(5769):1917-1921.
Diamond, J. 2005. *Collapse: How Societies Choose to Fail or Succeed*. Penguin Group, New York.
Durant, W. and A. Durant. 1968. *The Lessons of History*. Simon & Schuster, New York.
Editorial. 2006. State climatologist or company man? *Roanoke Times* 31 July: 6.
Feldt, G. 2006. Core issue missing in birth control war reports. *Women's eNews* 28 July http://www.womensnews.org/article.cfm/dyn/aid/2794.
Frazier, J. B. *Associated Press*. 2006. Pacific "dead zone" said to exceed fears. *Star-Telegram* 11 August http://www.apnews.myway.com/article/20060812/D8JEIE700.html.
Gaines, E. J. 2006. Where have you gone New Orleans? *National Geographic* 210(2):54-65.
Gibbs, W. W. 2006. Plan B for energy. *National Geographic* 210(2):102-108.
Ginn, B. 2006. The sale of the century. *Nature Conservancy* 56(3):20-25.
Greenpeace. 2006. Scientists: Southeast Asia losing billions to climate change. 18 July http://www.greenpeace.org/seasia/en/news/scientists-southeast-asia-los.
Halweil, B. 2006. Grain harvest flat in food and agricultural trends. *Vital Signs 2006-2007.* W.W. Norton and Company, New York.
Hawken, P., A. Lovins, and H. Lovins. 1999. *Natural Capitalism*. Little, Brown and Company, New York.
Hayden, T. 2006. Super storms: no end in sight. *National Geographic* 210(2):66-77.
Heinberg, R. 2005. *The Party's Over: Oil, War and the Fate of Human Societies*. New Society Publishers, Gabriola Island, British Columbia, Canada.
Howden, D. 2006. Eating the Amazon: the fight to curb corporate destruction. *The Independent* 17 July http://www.news.independent.co.uk/environment/article1181617.ece.
Jha, A. 2006. Forecast puts Earth's future under a cloud. *Guardian Unlimited* 15 August http://www.guardian.co.uk/science/story/0,,1844789,00.html.
Koch, T. and G. Roberts. 2006. Threat of sex-change sewage. *The Australian* 1 August http://www.theautralian.news.com.au/story/0,20867,19975923-23289,00.html.

Lewis, K. R. 2006. Ecology equals economy. *The Star-Ledger* 19 July http://www.nj.com/business/ledger/index.ssf?/base/business-3/1153287385257580.xml&coll=1.
Lomborg, B. 2001. *The Skeptical Environmentalist*. Cambridge University Press, Cambridge, UK.
Lovelock, J. 1988. *The Ages of Gaia*. W. W. Norton and Company, London.
Lovelock, J. 2006. *The Revenge of Gaia*. Basic Books, Perseus Books Group, New York.
Macartney, J. 2006. Misery and hunger stalk drought-hit grain basket. *Times Online* 14 August http://www.timesonline.co.uk/article/0,,25689-2311681.html.
Meadows, D., J. Randers, and D. Meadows. 2004. *The Limits to Growth: The 30 Year Debate*. Chelsea Green Publishing Company, White Junction, VT.
Mercuro, N., F., A. Lopez, and K. P. Preston. 1994. *Ecology, Law and Economics: The Simple Analytics of Natural Resource and Environmental Economics*. University Press of America, Lanham, MD.
Michaels, P. 1992. *Sound and Fury: The Science of Politics of Global Warming*. Cato Institute, Washington, DC.
Michaels, P. and R. C. Balline. 2000. *The Satanic Gases: Clearing the Air about Global Warming*. Cato Institute, Washington, DC.
National Geographic. 2006. Health: The National Safety Council 2003 Data. 210(2):21.
National Research Council. 1992. *Restoration of Aquatic Ecosystems: Science, Technology, and Pubic Policy*. National Academy Press, Washington, DC.
Nef. 2006. *The (Un)Happy Planet Index*. London: The New Economics Foundation. http://www.happyplanetindex.org.
New England Estuarine Research. 2006. New England sudden wetland dieback. 18 July http://www.wetland.neers.org.
Noueihed, L. 2006. Oil spill adds ecological crisis to Lebanon's agency. Reuters 27 July http://www.alertnet.org/thenews/newsdesk/L277727475.htm.
Pearce, F. 2006. Growing thirst of an arid Earth. *The Australian* 22 July http://www.theaustralian.news.com.au/story/0,20867,19866927-30417,00.html.
Pérez-Peña, R. and M. L. Wald. 2006. Electrical use hits new highs in much of U.S. *New York Times* 2 August http://www.nytimes.com/2006/08/02/us/02power.html?ex=115578200&en=244aec0381b61d36&ei=5070.
Price, D. 1995. Energy and human evolution. *Population and Environment* 16(4):301-319.
Rees, W. E. 1996. Revisiting carrying capacity: area-based indicators of sustainability. *Population and Environment* 17(3): 1-22.
Reuters. 2006. Where are the world's looming water conflicts? 2 August http://www.today.reuters.com/news/CrisesArticle.aspx?storyId=119639.
Revkin, A. C. 2006. NASA's goals delete mention of home planet. *New York Times* 22 July Late edition-final, Section A, p. 1, col. 1.
Sachs, J. D. 2006. Ecology and political upheaval. *Scientific American* 295(1):37.
Sagoff, M. 2004. *Price, Principle and the Environment*. Cambridge University Press, Cambridge, UK.
Sandell, C. and B. Blakemore. 2006. Making money by feeding confusion over global warming. *ABC News* 27 July http://www.abcnews.go.com/Technology/GlobalWarming/story?id=2242565&page=1.
Scholze, M., W. Knorr, N. W. Arnell, and I. C. Prentice. 2006. A climate-change risk analysis for world ecosystems. *Proceedings of the National Academy of Sciences* 103(35):13116-13120.
Shanker, T. 2006. Military plans tests in search for an alternative to oil-based fuel. *The New York Times* 14 May Late edition-final, Section 1, p. 16, col. 2.
Simon, J. L. 1980. Resources, population, environment: an oversupply of false bad news. *Science* 208:1431-1437.
Simon, J. L. 1981. *The Ultimate Resource*. Princeton University Press, Princeton, NJ.
Simon, J.L., ed. 1995. *The State of Humanity*. Blackwell Publishers, Cambridge, MA.
Socolow, R. H. and S. W. Pascala. 2006. A plan to keep carbon in check. *Scientific American* 295(3):50-57.
Speth, J. G. and P. M. Haas. 2006. *Global Environmental Governance*. Island Press, Washington, DC.
Sutherland, W. J. 2006. Predicting the ecological consequences of environmental change: a review of methods. *Journal of Applied Ecology* 43:599-616.
Tickell, C. 2006. Foreword, Page *i* in Lovelock, J. *The Revenge of Gaia*. Basic Books, Perseus Books Group, New York.
Tritch, T. 2006. The rise of the super-rich. *New York Times* 19 July http://www.select.nytimes.com/2006/07/19/opinion/19talkingpoints.html?hp.
Union of Concerned Scientists. 1992. *World Scientists' Warning To Humanity*. Cambridge, MA.
US Bureau of the Census. 2005. International Electronic Data Base. August. Suitland, MD.

Vidal, J. 2006. Cost of water shortage: civil unrest, mass migration and economic collapse. *Guardian Unlimited* 17 August http://www.guardian.co.uk/water/story/0,,1851712,00.html.
Wackernagel, M., N. B. Schulz, D. Deumling, A. C. Linares, and seven others. 2002. Tracking the ecological overshoot of the human economy. *Proceedings of the National Academy of Sciences* 99(14):9266-9277.
Walters, P. 2006. Climate is biggest security challenge. *The Australian* 10 June http://www.theaustralian.news.com.au/story/0,20867,19421121-2702,000.html.
Weisman, R. 2006. Business schools redefine their mission to society'. *Boston Globe* 9 July http://www.boston.com/business/articles/2006/07/09/business_schools_redefine_their_mission_to_society.
Weiss, K. R. 2006. Dark tides, ill winds. *Los Angeles Times* 1 August http://www.latimes.com/news/local/oceans/la-me-ocean1aug01,0,2672160.story.
World Health Organization. 2003. *Obesity and Overweight*. Geneva, Switzerland.
Worldwatch Institute. 2006. Vital signs 2006-2007: economic gains mask underlying crisis. 12 July http://www.worldwatch.org/node/4345.